Runoff and Water Quality from Sugarcane Farming

Synthesis Report
2009/10 to 2011/12 Wet Seasons

Mackay Whitsunday Region

Project outline

Under the Paddock to Reef program, paddock scale monitoring of water quality from various levels of management practices were implemented in selected Great Barrier Reef (GBR) catchments and agricultural industries (Carroll *et al.* 2012). As part of this program and in conjunction with *Project Catalyst*, two sugarcane blocks in the Mackay Whitsunday region were used to measure levels of herbicides, nutrients and sediments in runoff. Different sugarcane management strategies were investigated, with the emphasis on improving water quality with improved management practices.

The Victoria Plains site (uniform cracking clay) was divided into two treatments of soil, nutrient and herbicide management practices (Table 1). The Marian site (duplex soil) was divided into five treatments of soil, nutrient and herbicide management practices (Table 1). Two additional sites (Multi-block and Multi-farm) were used to measure the effects of changes in management strategies at larger scales (results not included in this synthesis report). Each treatment and site was instrumented to measure runoff and collect samples for water quality analyses (total suspended solids, total/filtered nutrients and herbicides).

Table 1: Summary of treatments at the paddock sites

	ABCD Classification[1]	Soil Management	Nutrient Management	Herbicide Management
Victoria Plains site – uniform cracking clay				
Treatment 1	CCC	1.5 m current practice	Generalised recommendation	Regulated[3]
Treatment 2	BBB	1.8 m controlled traffic	Six Easy Steps[2]	Non-regulated[4]
Marian site – duplex soil				
Treatment 1	CCC	1.5 m current practice	Generalised recommendation	Regulated[3]
Treatment 2	BCC	1.8 m controlled traffic	Generalised recommendation	Regulated[3]
Treatment 3	BBB	1.8 m controlled traffic	Six Easy Steps[2]	Non-regulated[4]
Treatment 4	BAB	1.8 m controlled traffic	Nitrogen replacement	Non-regulated[4]
Treatment 5	ABB	1.8 m controlled traffic, skip row	Six Easy Steps[2]	Non-regulated[4]

[1] – ABCD classifications for soil/sediment, nutrients and herbicides, respectively
[2] – Farm-specific nutrient management plan designed by BSES
[3] – Herbicides identified in the Chemical Usage (Agricultural and Veterinary) Control Regulation 1999
[4] – Herbicides not identified in the Chemical Usage (Agricultural and Veterinary) Control Regulation 1999

Key findings

Annual runoff was reduced by 14.5% with controlled traffic (1.8 m row spacing), despite the above average rainfall over the three year monitoring period

At the Victoria Plains site, we found that there was on average 14.5% less runoff from the 1.8 m row spacing (Treatment 2), despite receiving above average annual rainfall for the three year monitoring period (Figure 1). Furthermore, Treatment 2 also had a delayed onset of runoff (average 17 minutes) and a lower peak runoff rate (average 18%). These results suggest that by matching row spacing to machinery wheel spacing there will be reduced compaction, improved infiltration and consequently reduced runoff. At the Marian site, runoff measurements were confounded by the site flooding numerous times over the three year monitoring period. As such, it is not possible to derive accurate runoff figures for that site.

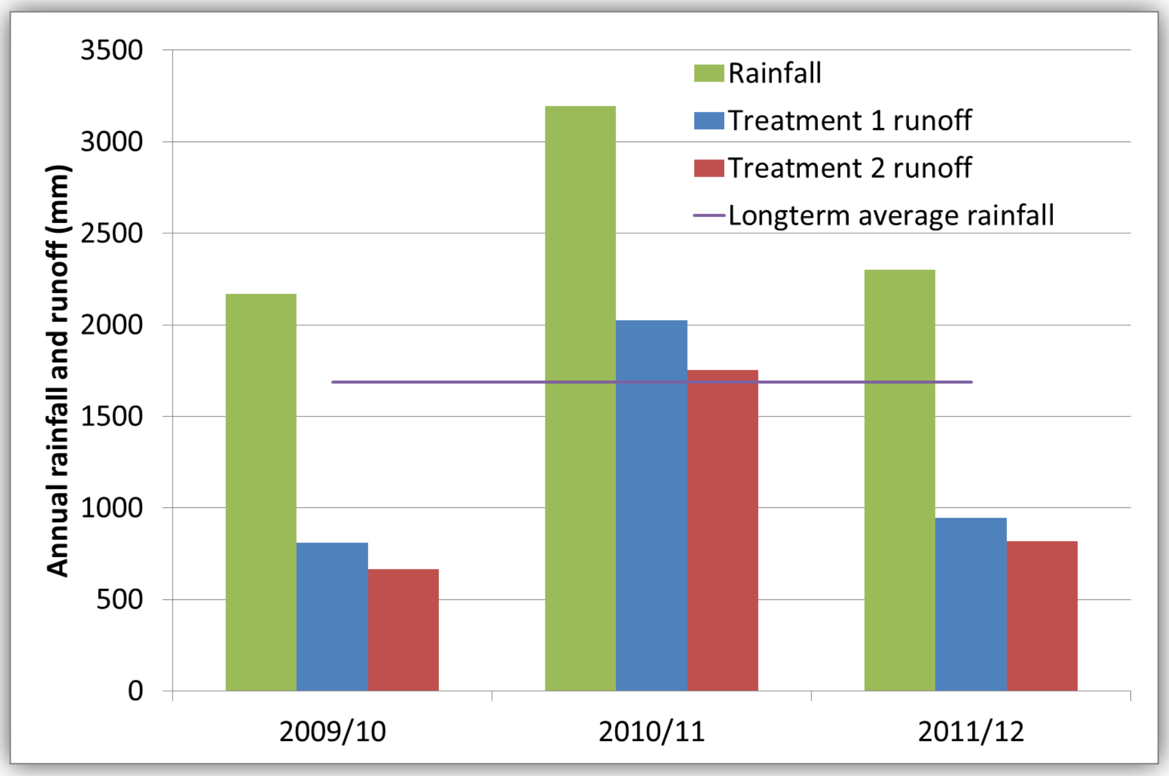

Figure 1: Victoria Plains annual runoff was reduced for the 1.8 m row spacing (Treatment 2) despite above average rainfall over the three year monitoring period (2009 - 2012)

Sediment loss was reduced by having a green cane trash blanket and by reducing cultivations

Although the Marian site flooded numerous times, water quality samples were collected during periods when the site was not flooded. Sediment concentration in runoff revealed that by maintaining ground cover (green cane trash blanket – GCTB) and reducing cultivation, there was reduced concentrations of sediment at both the Victoria Plains and Marian sites (Figure 2, Figure 3). Also, at the Victoria Plains site there was a reduced sediment load for the 1.8 m row spacing treatment due to the reduced runoff (Figure 1, Figure 4). The two treatments exhibited very similar sediment concentrations (307 mg/L for the 1.5 m conventional treatment and 301 mg/L for the 1.8 m controlled traffic treatment) (Figure 3), but the amount of sediment lost (sediment load) was reduced for the 1.8 m controlled traffic treatment in correlation with the reduced runoff for this treatment (Figure 1, Figure 4). Furthermore, the sediment load for the Victoria Plains site reduced over the three year period in relation to total suspended solids (TSS) concentrations and runoff amounts. However, the 2010/11 season the sediment load was similar to the 2009/10 season sediment load possibly as a result of the above average seasonal rainfall which drove higher runoff amounts, higher TSS concentrations and ultimately higher sediment loads than expected. It was also found that in the 2010/11 season the extreme rainfall, and consequently higher runoff velocities, caused the trash blanket to be washed up the sides and out the end of the furrow which increased the erosion potential of the soil and ultimately the TSS concentrations in runoff samples.

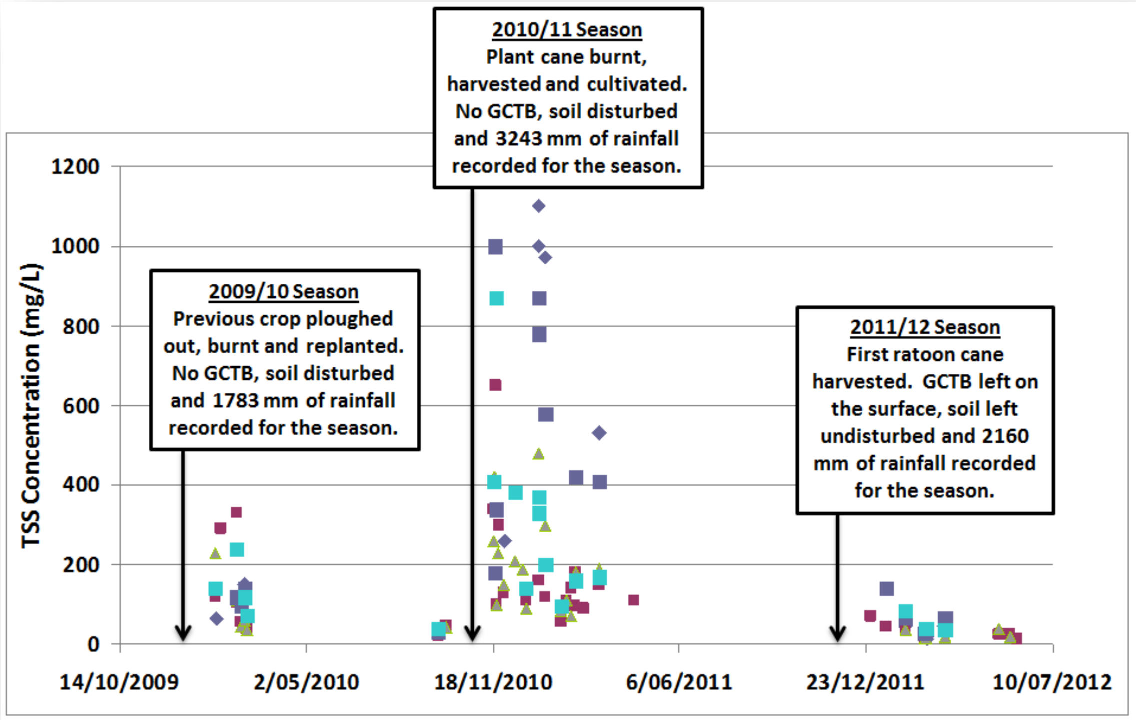

Figure 2: Sediment (total suspended solids - TSS) concentrations increased at the Marian site when there was a lack of surface ground cover (no green cane trash blanket - GCTB) and after cultivations.

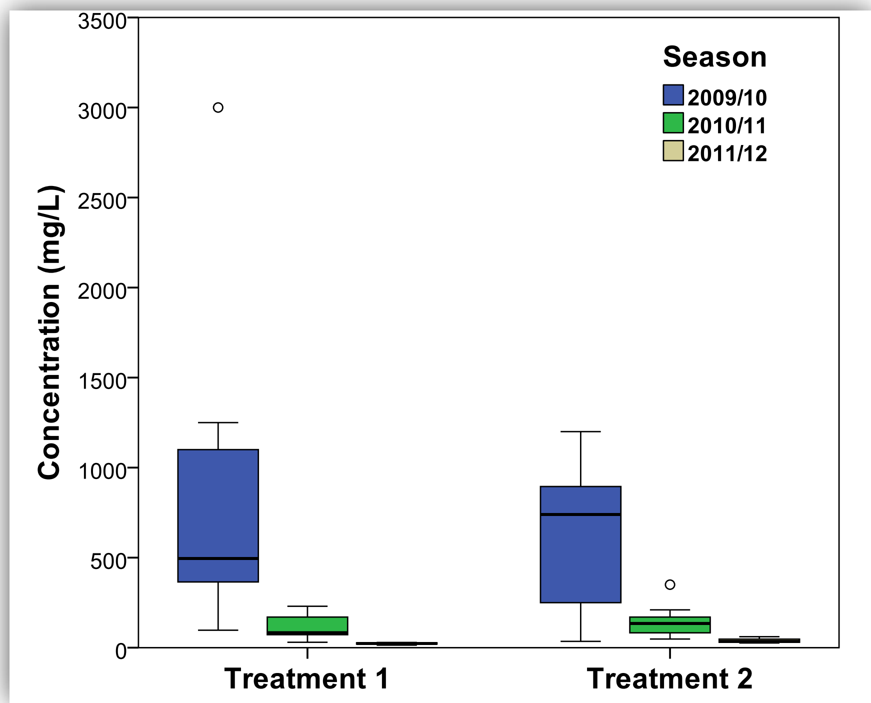

Figure 3: Sediment (total suspended solids - TSS) concentrations decreased over the three year monitoring period at Victoria Plains due to the retention of a green cane trash blanket (GCTB) and no cultivation being undertaken in the 2010/11 and 2011/12 seasons.

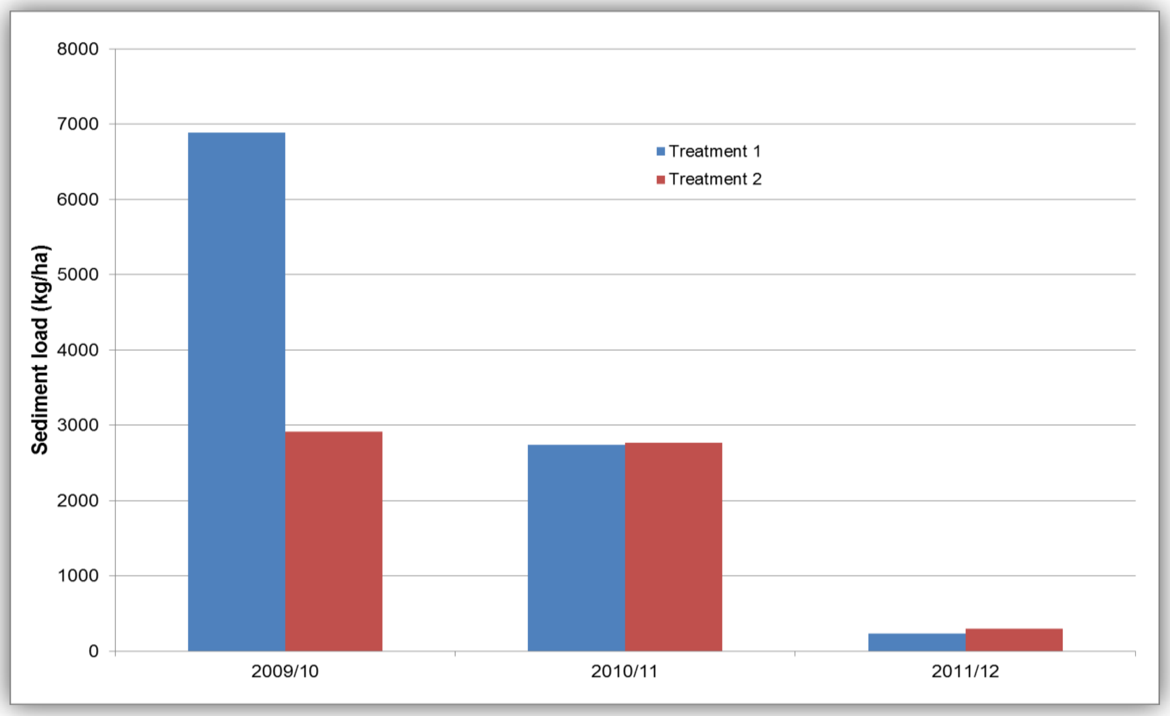

Figure 4: The sediment load for Victoria Plains decreased over the three year monitoring period due to the retention of a green cane trash blanket (GCTB) and no cultivation being undertaken in the 2010/11 and 2011/12 seasons. The extreme rainfall in 2010/11, and consequently higher runoff velocities, caused the trash blanket to be washed away increasing the erosion potential of the soil and ultimately the sediment load.

The amount of nutrients applied, timing of application and background soil nutrient levels were critical in reducing losses

At the Victoria Plains site, it was found that the greater the time between nutrient application and the first runoff event, the less nitrogen was lost (Figure 5). Also, the amount of infiltrating rainfall during this period, between nutrient application and the first runoff event, reduced the amount of nitrogen lost in runoff (Figure 5). The urea-N to NO_x-N ratio also appeared to decrease with the increase of time between nutrient application and the first runoff event, and the amount of infiltrating rainfall during this period (Figure 5). Furthermore, it was evident that the lower the application rate of nitrogen, the lower the amount of nitrogen was lost via runoff (Figure 5). Moreover, background nitrogen levels in the soil also had an effect on the amount of nitrogen lost via runoff, with the 2009/10 season having higher levels of soil nitrogen than the other seasons due to a legume fallow prior to the planting of the cane for this field trial (Figure 5). The larger losses are an economic loss for the grower (5-10% of nutrient applied).

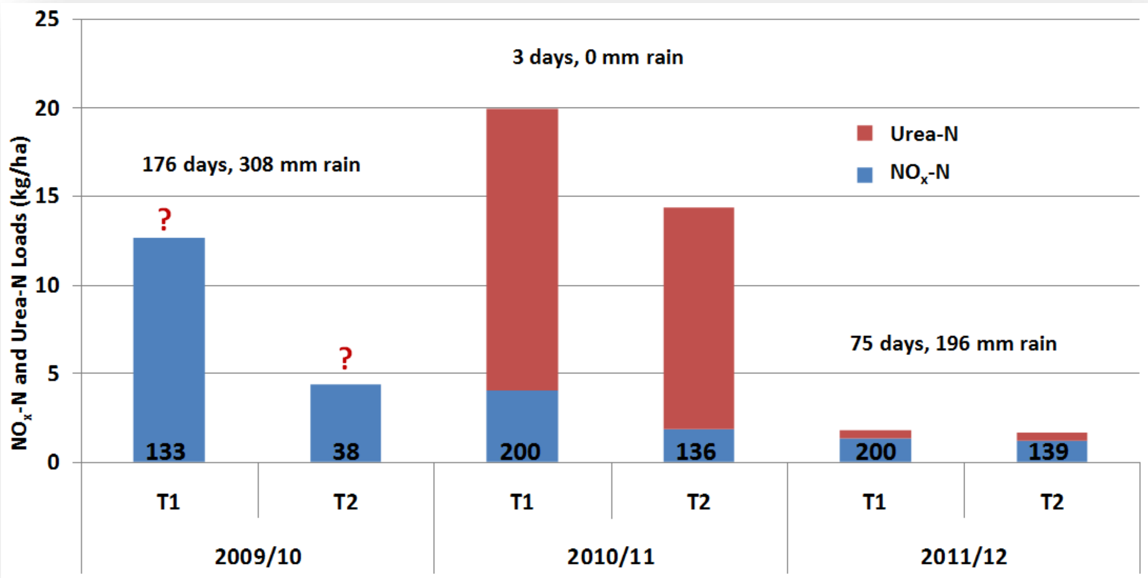

Figure 5: For Victoria Plains dissolved nitrogen loads and the urea-N to NO_x-N ratio in runoff decreased with the increase of time between nutrient application and the first runoff event as well as with the amount of infiltrating rainfall during this period. Nitrogen loads in runoff also decreased with lower application rates of nitrogen (kg N/ha).

Background soil phosphorus levels also had an effect on the concentration of filtered reactive phosphorus (FRP) found in runoff samples, with the Marian site exhibiting higher FRP concentrations in the runoff samples than the Victoria Plains site (Figure 6) as a result of the higher soil phosphorus levels found at the Marian site.

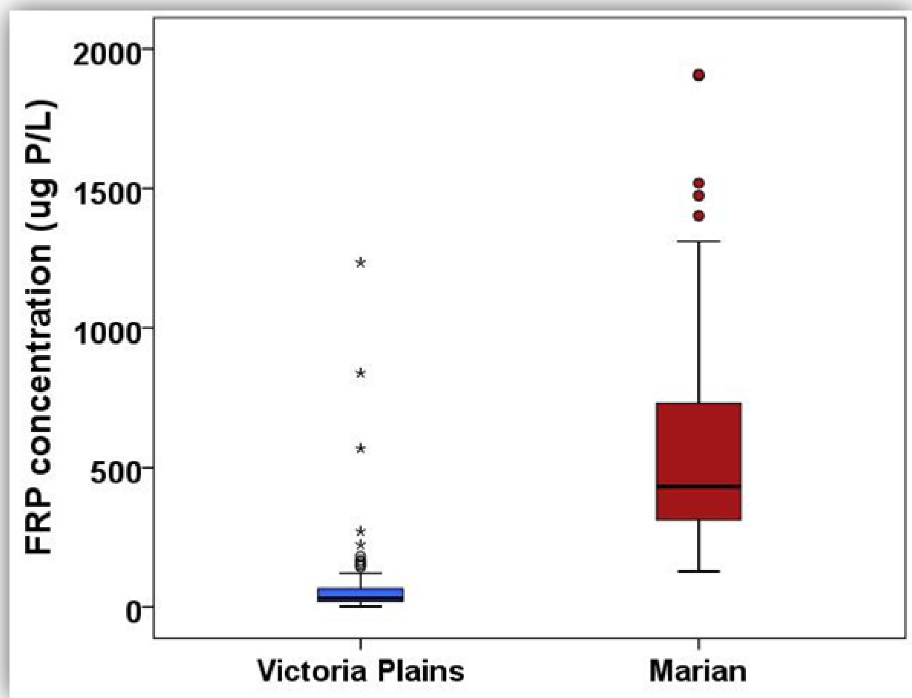

Figure 6: The filterable reactive phosphorus (FRP) concentration in runoff water samples was higher for the Marian site than the Victoria Plains site due to the higher soil phosphorus levels at the Marian site.

Timing of herbicide application was critical in reducing runoff losses

At the Victoria Plains site, the greater the time between herbicide application and the first runoff event, the less herbicide was lost in runoff (Figure 7, Figure 8). Also, the amount of infiltrating rainfall during this period, between the herbicide application and the first runoff event, reduced the amount of herbicide lost (Figure 7, Figure 8). It was also revealed that greater concentrations of herbicides tended to be lost if runoff-producing rainfall occurred in the period ~25 days after herbicide application as indicated by the red highlighted section in Figure 8.

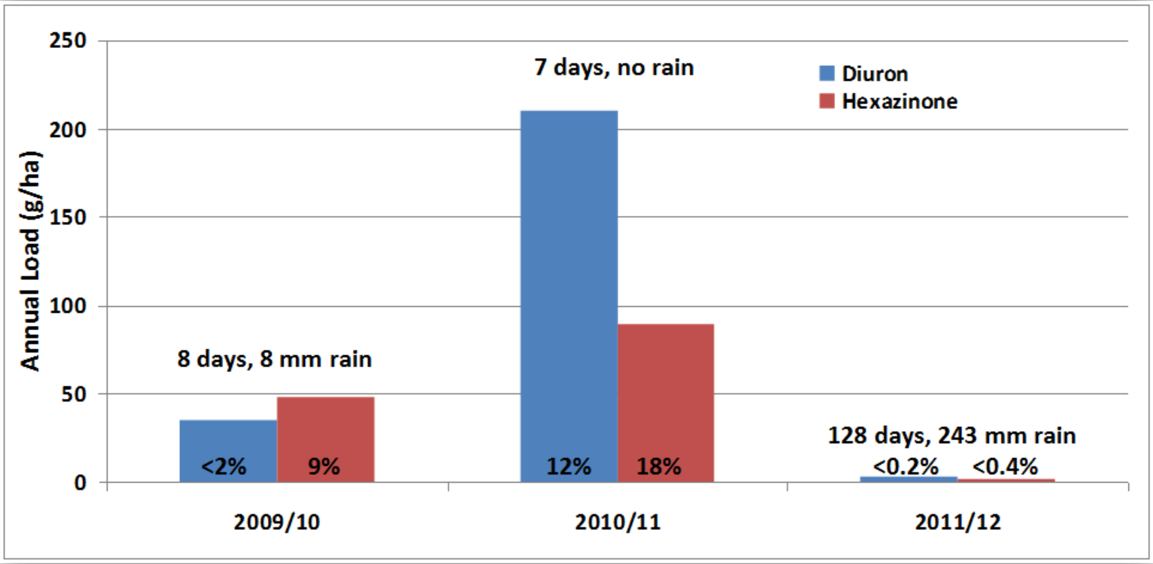

Figure 7: For Victoria Plains (Treatment 1) the herbicide loads in runoff decreased with the increase of time between herbicide application and the first runoff event, as well as with the amount of infiltrating rainfall during this period.

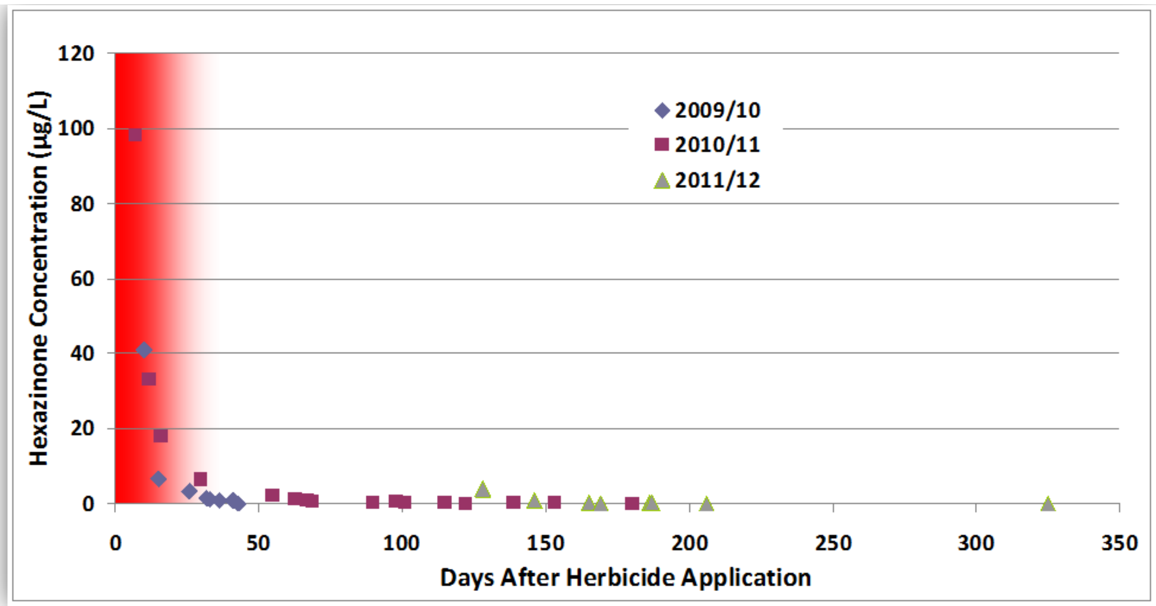

Figure 8: For Victoria Plains (Treatment 1) the herbicide concentration in runoff decreased with the increased time between herbicide application and the first runoff event. This revealed that greater concentrations of herbicides tended to be lost if runoff-producing rainfall occurred in the period ~25 days after herbicide application as indicated by the red highlighted section above.

Implementing best management practices did not significantly affect productivity

The study showed that by implementing best management practices (BMP's), there will not be a significant effect on productivity, with BMP's (B-class practices) performing as well as current management practices (C-class practices) even in a monitoring period that exhibited extreme weather events (Table 2, Figure 1). However, the results do indicate that some aspirational (innovative and new or A-class practices) management practices (nitrogen replacement and skip row) will not economically perform as well as current management practices in years with extreme weather events, as experienced during this three year monitoring period (Table 2, Figure 1).

Table 2: Productivity was not significantly affected by implementing best management practices (BMP), with the BMP (BBB) performing as well as current management practice (CCC).

	ABCD Classification[1]	Average Nitrogen Applied (kg/ha)	Average Cane Yield (t/ha)	Average sugar yield (t/ha)	Average sugar content (%)	Average net return ($/ha)*
Victoria Plains site – uniform cracking clay						
Treatment 1	CCC	178	82	14	16	2300
Treatment 2	BBB	104	77	12	16	2300
Marian site – duplex soil						
Treatment 1	CCC	195	93	16	14	1800
Treatment 2	BCC	195	91	12	13	2000
Treatment 3	BBB	163	84	11	14	1800
Treatment 4	BAB	90	73	10	13	1500
Treatment 5	ABB	161	58	10	13	1100

[1] – ABCD classifications for soil/sediment, nutrients and herbicides, respectively
*Excluding irrigation, other fertiliser (nutrients) and fixed costs other than harvesting

Nevertheless, the Marian site skip row (aspirational Treatment 5) still produced on average 60% of the cane yield of the top performing treatment (Treatment 1), despite having half the area planted to cane (Table 2). Moreover, this treatment would have had a better average net return if the peanut skip row crop could have been successfully planted and harvested every season. Furthermore, the nitrogen replacement treatment (Treatment 4) did not perform well due to the tight constraints on the nitrogen applied only being equivalent to the biomass produced. This resulted in a nitrogen deficiency in the cane as a result of nitrogen being lost via pathways not included in the methodology, such as de-nitrification which was a significant factor at this site due to flooding and waterlogging. Moreover, further work is required to improve the methodologies for these aspirational management practices and prove them to be a viable and productive alternative to current management practices.

Overall, these results are not surprising and are all supported by other studies. For further details please refer to the Mackay Whitsunday Paddock to Sub-catchment Scale Water Quality Monitoring of Sugarcane Management Practices Final Report for the 2009/10 to 2011/12 Wet Seasons (Rohde *et al*. 2013).

References:

Carroll C, Waters D, Vardy S, Silburn DM, Attard S, Thorburn PJ, Davis AM, Halpin N, Schmidt M, Wilson B, Clark A (2012) A Paddock to reef monitoring and modelling framework for the Great Barrier Reef: Paddock and catchment component. *Marine Pollution Bulletin* **65**, 136-149.

Rohde, K., McDuffie, K., and Agnew, J. (2013). *Paddock to Sub-catchment Scale Water Quality Monitoring of Sugarcane Management Practices. Final Report 2009/10 to 2011/12 Wet Seasons, Mackay Whitsunday Region.* Department of Natural Resources and Mines, Queensland Government for Reef Catchments (Mackay Whitsunday Isaac) Limited, Australia.

Authorship
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